A PROTEROZOIC $^{40}Ar/^{39}Ar$ AGE FOR THE SÖDERFJÄRDEN IMPACT STRUCTURE, FINLAND.

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Introduction and Geologic Background: The 6.6 km-diameter Söderfjärden impact structure in western Finland is a prime terrestrial example of a polygonal complex impact crater [1]. The circular-polygonal topographic depression was earlier proposed as of impact origin [2], but only recently has compelling evidence for shock metamorphism been demonstrated [3]. The impact crater lies within ~1.88 Ga Svecofennian granitoids (the 'Vaasa Granite') of the Baltic Shield [2] and is filled with a thick cover of Lower Cambrian marine clastics and Quaternary glacial deposits that conceal its annular moat and central uplift [2-4].

Previous Age Determinations: The age of the Söderfjärden impact is still poorly constrained. In lack of good outcrop of melt-bearing impactites, previous age estimates for the impact entirely relied on a single attempt of K/Ar dating of the brecciated Paleoproterozoic crystalline bedrock (with apparent ages around ~1.3 Ga) [5] and the biostratigraphic age estimates for the post-impact crater fill sequence. However, from the intra-crater stratigraphy it remains unclear whether the Söderfjärden event was an Early Cambrian marine impact [6] or whether the crater had formed earlier in an on-shore setting [4] and was flooded in post-impact time. Age estimates for Söderfjärden generally range between ~600 Ma and ~520 Ma [4-7], thus encompassing the latest Proterozoic and the earliest Paleozoic.

New $^{40}Ar/^{39}Ar$ Results and Interpretation: The relatively recent recognition of dark veins of likely friction-melt origin in an area restricted to the crater rim domain [4, 8] provides new sample material for isotopic dating. The inset image of Fig. 1 shows a local boulder specimen with a typical dark melt breccia in sharp contact with the host granitoid; the gray melt breccia domain carries abundant quartz and feldspar fragments and locally contains secondary sulfides, whereas the fluidal black melt domain is largely clast-free. After irradiation in the TRIGA (Denver) nuclear reactor, two apparently fresh black melt rock chips 355-500 µm in size were selected for $^{40}Ar/^{39}Ar$ dating at the Western Australian Argon Isotope Facility, Curtin University, using the 1081.0 ± 1.2 Ma Hb3gr standard (see [9] for technical details and procedures). Despite the fresh appearance of the melt samples, step-heating analysis yielded two disturbed, hump-shaped, age spectra, indicating substantial alteration; no precise and accurate age can be derived from this data set. Both age spectra reach their maxima at ~640 Ma (Fig. 1). In analogy to other bell-shaped age spectra for altered impact melt rocks and pseudotachylitic breccias [10, 11], the oldest apparent step ages must be considered a strict minimum age for the formation of the melt. Considering the effects of alteration and possible Ar recoil redistribution on the Ar isotopic system and assuming that the dark melt veins were produced during the impact (see discussion in [8]), the $^{40}Ar/^{39}Ar$ data suggest that the Söderfjärden impact structure is (significantly) older than 640 Ma. The new isotopic age constraints contradict a Cambrian marine impact scenario and argue for the drowning of a much older, Proterozoic, continental impact crater during the Early Paleozoic marine transgression.

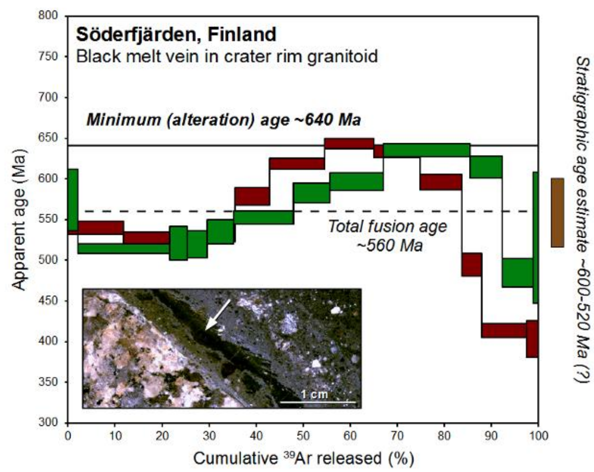

Fig. 1: Combined $^{40}Ar/^{39}Ar$ age spectra for two black melt vein samples (arrow, inset image) from Söderfjärden.

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